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Efficacy and residual toxicity of plant product extracts against *Aphis gossypii* and *Bemisia tabaci* on potato (*Solanum tuberosum*)

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ABSTRACT

Efficacy and residual toxicity of seven plant product extracts in hexane, methanol and ethyl acetate were evaluated against cotton aphid, *Aphis gossypii* and whitefly, *Bemisia tabaci* on potato under controlled condition and efficacy of effective extracts were further evaluated under field condition at Central Potato Research Institute Campus, Modipuram during 2012-13 and 2013-14, respectively. The importance of aphids and whitefly is mainly due to their role in spread of viruses in potato crop. The highest mortality of whitefly (65.91%) was recorded in methanol bark extract of dalchini *(Cinnamomum zeylanicum)* followed by hexane bark extract of jatamansi (*Nardostachus jatamansi)* (64.3%) and methanol extract of coriander (*Coriander sativus)* (64.03%) after 72 hr of release as compared to control. In case of aphid, the highest mortality (44.06%) was recorded in ethyl acetate seed extract of malkangni *(Celastrus paniculatus)* followed by methanol extract of dalchini (40.81%) and methanol extract of jatamansi (40.72%) after 72 hr of release as compared to control. Periodic toxicity data revealed that all the tested extracts lost their toxicity within 3-4 days after spray. Hexane extract of jatamansi gave maximum PT values 53.81 and 70.3 against aphid and whitefly, respectively. Overall, hexane bark extract of jatamansi was even effective against whitefly and aphids under field condition and recorded 296.8 q tuber yield which is almost at par with methanol bark extract of dalchini (301.2 q). However, tuber yield data did not reveal significant differences among the plant product treatments with frequent spraying of plant product. This study suggested that plant product extract sprays may be included in IPM program to reduce the dependence on popular toxic chemicals to suppress aphid and whitefly population effectively on the potato crop.

Key words: Aphid, Plant product extracts, Potato, Toxicity, Whitefly

Potato (*Solanum tuberosum* L.) is an important cash crop grown all over the country under a wide range of agro climatic conditions. However, the production of this crop is hampered by various biotic and abiotic factors. Insect -pests damaging this crop are one of the main factors for its low production. Aphids (*Aphis gossypii)* and whiteflies *(Bemisia tabaci)* as a vector of viral diseases have a profound adverse effect on potato seed quality and consequently on overall potato yield (Bhatnagar 2013, Chandel *et al*. 2010). These insects have become a threat to crop by sucking the sap directly from the tender parts of plant and also act as a vector in transmitting important viruses, thereby affecting tuber yield and its market value (Bhatnagar 2013, Bhatnagar and Singh 2013, Dharpure 2002).

Many synthetic insecticides have been used to suppress the insect population on potato. However, these chemicals are expensive and their indiscriminate use is hazardous to human health and the environment. Therefore, there is an urgent need to develop and evaluate new bioactive products, which are pest specific, non-toxic to humans and other beneficial organisms, bio-degradable, less prone to the development of pest resistance and also less expensive. Keeping in view the importance of these insect vectors of potato crop in North-western plains of India, experiment were carried out to assess the efficacy and residual toxicity of seven plant product extracts against cotton aphid and whitefly on potato.

MATERIALS AND METHODS

The culture of aphids and whiteflies were raised separately on potted potato plants (6 leaf stage) in the laboratory at the Central Potato Research Institute Campus, Modipuram during 2012-13. Plants of cv. Kufri Pukhraj were grown in clay pots for evaluation of bioassay and residual toxicity. For confirmation of efficacy of plant product extract, field trial was also conducted on early crop at Modipuram during 2013-14 using cv. Kufri Pukhraj.

Some locally available aromatic angiosperm, i.e. majuphal (*Quercus infectoria),* malkangni *(Celastrus paniculatus),* jatamansi (*Nardostachus jatamansi),* dalchini *(Cinnamomum zeylanicum),* coriander (*Coriander sativus)*

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and shikakai (*Acacia cocinna)* were extracted in hexane, acetone and methanol through soxhlet extraction. Seven extracts were screened on caged potato plants separately for their efficacy and residual toxicity against aphid and whitefly at 10 000 ppm concentration. The calculated amount of the mother extract was incorporated into 25 ml of sterile distilled water using an auto pipette. For proper mixing of extract with water, 500 ul tween-20 was added in the solution. This plant solution was sprayed on the potato leaves and allowed to shade dry. Nine treatments include seven plant extracts, recommended insecticide (imidacloprid 17.5 SL) as a check and control (water spray) for bioefficacy and residual toxicity study. Plant extracts were used as T_1-methanol extract of majuphal, T_2-ethyl acetate extract of malkangni seed, T_3-hexane extract of jatamansi bark, T_4-methanol extract of dalchini bark, T_5-methanol extract of coriander, T_6-methanol extract of shikakai and T_7-hexane extract of majuphal. Each treatment was replicated thrice and thirty aphids and whiteflies (pre starved) were released separately on sprayed potato plants. The observation on percent mortality of aphids and whiteflies were recorded 24, 48 and 72 hr after the release of insects. Experiments were carried out at 30+2°C and 70-80% relative humidity. The corrected percent mortality was calculated as

$$\text{Corrected mortality (\%)} = \frac{\text{Mortality in treatment (\%)- Mortality in control (\%)}}{\text{100- Mortality in control (\%)}} \times 100$$

Similarly, persistence toxicity of seven plant extracts was checked against aphids and white flies. Healthy potato plants were sprayed with each plant product extract with the help of atomizer on potted plants. Thirty aphids and whiteflies were released on treated potted plants separately and mortality was recorded at 1, 2, 3, 4, 5, and 10 days after respective plant extract spray. This was continued till no mortality was observed and PT values were calculated according to Rao and Sharma (1988) as follows:

Periodical toxicity (PT) = Period for which toxicity observed (P) × Average toxicity (T)

Field trial was planted on 15 September as early crop using cv. Kufri Pukhraj. The crop was grown by following recommended agronomic practices for this region. Only five effective plant products was sprayed 7 days interval on potato along with a check (Imidacloprid 17.8 SL-4ml/10l) and water spray. Seven treatments were repeated three times. First spray was given after the appearance of the pest and subsequent spray after a gap of seven days. Observations of whiteflies and aphids were recorded one day after treatment from randomly selected 10 plants following standard sampling technique. Total tuber yield, and disease incidence were also recorded at the time of harvesting. Data were subjected to statistical analysis and transformed using square root transformations √x+0. 5.

RESULTS AND DISCUSSION

Results revealed that mortality of *A. gossypii* and *B. tabaci* against tested plant extracts differed significantly compared to check insecticide and unsprayed treatments. The mortality of plant product extract treatments ranged from 0.0 to 28.65 and 18.3 to 57.11 at 24 hr against aphids and whiteflies, respectively (Table 1). Expectedly, the highest

Table 1 Effect of plant product extracts on mortality (cumulative) of *Aphis gossypii* and *Bemisia tabaci*

Treatment (plant product extract)	*Aphis gossypii*			*Bemisia tabaci*		
	After 24 hr	After 48 hr	After 72 hr	After 24 hr	After 48 hr	After 72 hr
T_1-(*Quercus infectoria*) methanol extract of majuphal	3.04(8.96)	4.22(17.85)	4.79 (23.86)	4.99 (25.81)	5.18 (27.97)	5.57 (32.07)
T_2-(*Celastrus peniculatus*) ethyl acetate extract of malkangni seed	5.39 (28.65)	5.75 (32.65)	6.67 (44.06)	7.29 (52.72)	7.45 (55.19)	7.73 (59.31)
T_3-(*Nardostachus jatamansi*) hexane extract of jatamansi bark	4.66 (21.53)	5.24 (27.11)	6.38 (40.72)	7.38 (54.16)	7.71 (59.07)	8.04 (64.30)
T_4-(*Cinnamon zeylanvium*) methanol extract of dalchini bark	5.04 (24.95)	5.75 (32.65)	6.42 (40.81)	7.59 (57.11)	8.02 (63.79)	8.15 (65.91)
T_5-(*Coriander sativus*) methanol extract of coriander	3.73 (14.42)	5.31 (28.57)	6.01 (36.55)	7.45 (55.02)	7.66 (58.21)	8.03 (64.03)
T_6-(*Acacia cocinna*) methanol extract of shikakai	0.71 (0.00)	1.27 (1.75)	1.45 (2.10)	4.33 (18.30)	4.65(21.38)	5.44 (29.30)
T_7-(*Quercus infectoria*) hexane extract of majuphal	4.66 (21.44)	5.40 (28.94)	5.90 (34.85)	6.93 (47.91)	7.16 (51.16)	7.47 (55.71)
T_8-(check) imidacloprid 17.5SL (4ml/10l)	9.45 (88.96)	9.84 (96.43)	9.88 (97.10)	9.74 (94.50)	9.75 (94.83)	10.0 (99.57)
T_9-(control)-water spray	0.71 (0.00)	0.71 (0.0)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
SEm±1	0.39	0.30	0.41	0.34	0.34	0.36
CD (P=0.05)	1.177	0.912	1.258	1.030	1.141	1.091

*Data in parenthesis indicate actual values. Using Square root transformation x = √(x + 0.50)

Table 2 LC_{50} of plant product extracts against *Aphis gossypii* and *Bemisia tabaci*

Treatments (plant product extract)	*Aphis gossypii*			*Bemisia tabaci*		
	Regression equation	LC_{50}	Fiducial limits	Regression equation	LC_{50}	Fiducial limits
Methanol extract of majuphal (*Quercus infectoria)*	Y=6.24X+1.398	0.03778	UL 0.03119 LL 0.02861	Y=11.6X-1.210	0.03429	UL 0.04000 LL 0.03214
Ethyl acetate extract of malkangni seed (*Celastrus paniculatus)*	Y=9.00X+0.290	0.03335	UL 0.03141 LL 0.02736	Y=11.9X-1.251	0.03351	UL 0.03807 LL 0.03164
Hexane extract of jatamansi bark (*Nardostachus jatamansi*)	Y=7.08X+1.137	0.03510	UL 0.03359 LL 0.02732	Y=10.1X-0.294	0.04452	UL 0.03751 LL 0.03125
Methanol extract of dalchini bark (*Cinnamon zeylanicum*)	Y=7.44X+1.002	0.03437	UL 0.03232 LL 0.02717	Y=8.09X+0.919	0.03187	UL 0.03707 LL 0.02983
Methanol extract of coriander (*Coriander sativus*)	Y=9.18X+0.059	0.03448	UL 0.03119 LL 0.02861	Y=9.00X+0.290	0.03335	UL 0.03959 LL 0.03110
Hexane extract of majuphal (*Quercus infectoria*)	Y=8.31X+0.410	0.03559	UL 0.03500 LL 0.02886	Y=6.85X+1.396	0.05163	UL 0.04524 LL 0.03080

mortality was recorded in insecticide treatment while no mortality in unsprayed treatment. The ethyl acetate extract of *C. paniculatus* was more potent and has given the highest mortality (28.6%) followed by methanol extract of *C. zeylanicum* (24.9%) against *A. gossypii* after one day of spraying of plant product extracts. The lowest mortality was observed in case of methanol extract of *A.cocinna* (0.0%), it was closely followed by methanol extract of *Q. infectoria*, which resulted in 8.9% mortality. Similar results have also been observed even after 3 days after release of aphid, where as the ethyl acetate extract of *C. paniculatus* has resulted 44% and methanol extract of *C. zeylanicum* mortality 40.8% and thus, both proved moderality effective against *A. gossypii*. The highest mortality of whiteflies was recorded in methanol bark extract of *C. zeylanicum* (57.1%) followed by hexane bark extract of *N. jatamansi* (54%) and methanol extract of *C. sativus* (55%) after 24 hr of release of whitefly. Almost similar trend of mortality of aphid and whitefly was observed in plant product extract treatments even after 48 and 72 hr. The plant extracts are moderately toxic to whitefly and aphids as compared to insecticides. Most of the tested plant product extracts were acting as a repellent or antifeedent in action against aphids and whiteflies. The relative toxicity of effective plant extracts reveals that ethyl acetate extract

Table 3 Residual toxicity of plant product extracts against *Aphis gossypii* and *Bemisia tabaci*

Treatment (Plant product extract)	Percent mortality observed after treatment at different days						P*	T**	PT	Order of toxicity
	1	2	3	4	5	10				
T_1-(*Quercus infectoria*) methanol extract of majuphal	8.96 (25.81)	8.89 (4.10)	6.01 (2.16)	4.0			4 (3)	6.96 (10.96)	27.86 (32.07)	7 (8)
T_2-(*Celastrus peniculatus*) ethyl acetate extract of malkangni seed	28.65 (52.72)	11.41 (4.12)	8.0 (2.47)	4.0 (2.0)			4 (4)	13.01 (15.32)	52.06 (61.31)	3 (5)
T_3-(*Nardostachus jatamansi*) hexane extract of jatamansi bark	21.53 (54.16)	13.70 (5.23)	9.0 (4.91)	5.58 (4.0)	4.0 (2.0)		5 (5)	10.76 (14.06)	53.81 (70.30)	2 (2)
T_4-(*Cinnamon zeylanvium*) bark	24.95 (57.11)	8.07 (6.68)	7.70 (2.12)	4.0			4 (4)	11.18 (21.97)	44.72 (65.91)	4 (4)
T_5-(*Coriander sativus*) methanol extract of coriander	14.42 (55.02)	14.15 (5.82)	7.98 (3.19)	2.0 (2.0)			4 (4)	9.67 (16.50)	38.55 (66.03)	5 (3)
T_6-(*Acacia cocinna*) methanol extract of shikakai	1.75 (18.30)	0.35 (7.92)	(5.0)	(3.08)			2 (4)	1.05 (8.57)	2.10 (34.30)	8 (7)
T_7-(*Quercus infectoria*) hexane extract of majuphal	21.44 (47.91)	7.50 (4.55)	5.91 (4.0)	(3.55)			3 (4)	11.61 (14.92)	34.85 (59.71)	6 (6)
T_8-(check) imidacloprid 17.5SL	100 (98.50)	100 (95.0)	90 (84.74)	86.6 (78.5)	5 (62.5)		7 (7)	60.94 (59.89)	426.6 (419.24)	1 (1)
T_9-(control- water spray)										

* Period for which toxicity persisted, ** Average residual toxicity, Data in parenthesis indicate residual toxicity against *Bemisia tabaci*

Table 4 Average aphids population on potato under field condition

Treatment	Average weekly incidence of aphid population per 10 plants								
	15.10.	16.10.	17.10.	21.10.	29.10.	07.11.	19.11.	25.11.	03.12.
T_1-Methanol extract of majuphal	1.44 (1.67)	2.88 (8.00)	2.53 (6.00)	2.40 (6.67)	3.00 (8.67)	3.44 (11.33)	4.60 (20.6)	4.97 (24.33)	4.52 (20.00)
T_2-Ethyl acetate extract of malkangni seed	1.05 (0.67)	2.18 (4.33)	2.09 (4.00)	2.26 (4.67)	2.78 (7.67)	2.86 (7.67)	3.94 (15.3)	4.59 (20.67)	4.10 (16.67)
T_3-Methanol extract of dalchini bark	1.56 (2.00)	2.71 (7.00)	2.53 (6.00)	2.67 (6.67)	3.18 (9.67)	3.07 (9.00)	4.06 (16.3)	4.88 (23.33)	4.86 (23.33)
T_4-Hexane extract of jatamansi bark	1.17 (1.00)	2.26 (4.67)	2.47 (5.67)	2.66 (6.67)	2.88 (8.00)	2.89 (7.67)	4.60 (20.6)	5.10 (25.67)	4.15 (17.00)
T_5-Methanol extract of coriander	1.44 (1.67)	2.47 (5.67)	2.11 (4.00)	2.48 (5.67)	3.02 (8.67)	3.09 (7.67)	4.09 (16.3)	4.62 (21.00)	4.90 (23.67)
T_6-Imidacloprid-17.5 SL, (4ml/10l)	1.34 (1.33)	1.00 (0.67)	0.71 (0.00)	1.68 (2.33)	1.84 (3.00)	2.18 (4.33)	3.11 (9.33)	3.23 (10.00)	3.13 (9.33)
T_7-Control-(water spray)	1.44 (1.67)	3.42 (11.33)	3.58 (12.33)	3.48 (11.67)	3.79 (14.00)	3.48 (11.67)	5.36 (28.33)	5.44 (29.33)	5.43 (29.33)
SEm±1	0.213	0.248	0.194	0.311	0.230	0.200	0.265	0.267	0.33
CD (P=0.05)	NS	0.764	0.600	0.960	0.709	0.617	0.819	0.824	1.028

Using Square root transformation, $x = \sqrt{(x + 0.50)}$, seven sprays of plant product on 14.10., 20.10., 28.10., 06.11, 18.11, 24.11 and 02.12.13

of malkangni seed has recorded the highest toxicity against *A. gossypii* followed by methanol extract of dalchini bark and hexane extract of jatamansi bark. Methanol extract of dalchini bark, hexane extract of jatamansi bark and methanol extract of coriander gave the highest toxicity against whitflies (Table 2). Saradamma *et al*. (1988) also reported that plant extracts of Neem, Eupatorium, Clerondendron, Nerium and Thevatia could reduce the population of *A. gossypii* below economic threshold level in okra crop.

It was also observed that the hexane extract of *N. jatamansi* has recorded the highest periodic toxicity value (53.8) closely followed by ethyl acetate extract of *C. paniculatus* (52.0) against *A. gossypii*. However, the methanol extract of *A. cocinna* and *Q. infectoria* had the lowest PT values. Similarly, hexane bark extract of *N. jatamansi* and methanol extract of *C. sativus* recorded the highest periodic toxicity values 70.3 and 66.0, respectively, it was closely followed by methanol bark extract of *C. zeylanicum* (65.9) and ethyl acetate extract of *C. paniculatus* (61.3) (Table 3).

Table 5 Average whiteflies population on potato under field condition

Treatment	Average weekly incidence of whitefly population per 10 plants								
	15.10.	16.10.	17.10.	21.10.	29.10.	07.11.	19.11.	25.11.	03.12.
T_1-Methanol extract of majuphal	2.11 (4.00)	2.18 (4.33)	1.93 (3.33)	1.57 (2.33)	2.20 (4.33)	2.60 (6.33)	2.84 (7.67)	1.84 (3.67)	1.72 (3.00)
T_2-Ethyl acetate extract of malkangni seed	2.02 (3.67)	2.08 (4.00)	2.30 (5.00)	1.77 (2.67)	1.94 (4.33)	1.88 (3.00)	2.62 (6.67)	1.87 (3.67)	1.48 (1.30)
T_3-Methanol extract of dalchini bark	1.93 (3.33)	1.34 (1.33)	1.68 (2.33)	0.71 (0.00)	1.39 (1.67)	1.48 (2.00)	2.55 (6.33)	1.66 (2.67)	1.10 (1.00)
T_4-Hexane extract of jatamansi bark	2.02 (3.67)	1.90 (3.33)	1.92 (3.33)	1.05 (0.67)	1.57 (2.33)	2.11 (4.00)	2.62 (6.67)	2.20 (4.33)	1.18 (1.33)
T_5-Methanol extract of coriander	2.20 (4.33)	1.74 (2.67)	1.68 (2.33)	1.48 (2.00)	1.87 (3.67)	2.60 (6.33)	1.64 (2.67)	2.77 (7.67)	2.22 (4.67)
T_6-Imidacloprid- 17.5 SL,(4ml/10l)	2.16 (4.33)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.39 (1.67)	1.10 (1.00)	2.11 (4.00)	0.71 (0.00)	1.00 (0.67)
T_7-Control-(water spray)	2.26 (4.67)	2.86 (7.67)	3.18 (9.67)	3.48 (11.67)	3.34 (10.67)	3.17 (9.67)	3.53 (12.00)	3.57 (12.33)	2.67 (6.67)
SEm±1	0.196	0.221	0.189	0.251	0.44	0.240	0.336	0.393	0.411
CD (P=0.05)	NS	0.681	0.583	0.773	NS	0.740	1.036	1.212	NS

Using square root transformation, $x = \sqrt{(x + 0.50)}$, seven sprays of plant product on 14.10., 20.10., 28.10., 06.11, 18.11, 24.11 and 02.12.13

Table 6 Tuber yield, attributing characters and disease incidence under field condition

Treatment	Germination (%)	Over size tubers (%)	Seed size tubers (%)	Disease (%)	Total tuber yield (q/ha)
T_1-Methanol extract of majuphal	84.67	65.90	35.90	33.03	226.43
T_2-Ethyl acetate extract of malkangni seed	92.67	70.03	29.87	35.63	253.43
T_3-Methanol extract of dalchini bark	88.33	74.90	25.00	23.77	301.20
T_4-Hexane extract of jatamansi bark	88.33	71.27	28.63	39.43	296.87
T_5-Methanol extract of coriander	91.67	74.73	25.17	31.13	278.13
T_6-Imidacloprid-17.5 SL,(4ml/10l)	85.00	67.80	32.10	27.27	326.23
T_7-Control-(water spray)	86.67	73.07	26.83	39.53	224.33
SEm±1	4.05	5.43	5.15	4.65	30.85
CD (P=0.05)	NS	NS	NS	NS	NS

In the field trial significantly low incidence of whiteflies and aphid population were recorded in all the tested plant extract treatments after frequent spray application as compared to control treatment (water spray). The minimum incidence of whitefly (1.34-2.11) was recorded in menthanol bark extract of dalchini followed by hexane bark extract of jatamansi (0.71- 2.62) during crop growth, showing all most same trend as under controlled conditions (Table 5). In case of aphid population, the minimum incidence was recorded in ethyl acetate seed extract of malkangni followed methanol extract of jatamansi as compared to control (Table 4).

The percent germination, disease incidence and total tuber yield did not show significant difference among the treatments. However, among the plant products treatments, maximum yield (301.2 q) was recorded in the protected treatments of menthanol extract of dalchini bark closely followed by hexane extract of jatamansi bark (Table 6).

Over all, hexane extract of jatamansi bark was equally effective against both the insect under field condition and recoded tuber yield of 296.8 q, closely at par by methanol extract of dalchini bark (301.2 q). The plant product extracts proved superior in terms loss of toxicity within 3-4 days after spraying on crop as against popular insecticide imidacloprid which took 7-8 days. These results clearly established that methanol bark extract of *C. zeylanicum* and hexane bark extract of *N. jatamansi* were most toxic against whiteflies. Besides ethyl acetate seed extract of *C. Peniculatus* and methanol extracts of *C. zeylanicum* and *N. jatamansi* were also toxic against aphids on potato crop. The present findings are in agreement with the earlier findings reported by Saradamma *et al*. (1988) and Bhatnagar and Sharma (1991). Similarly, Pal *et al*. (2000) also reported that plant extracts completely lost their residual life within 4-5 days. Hexane extract of *N. jatamansi* gave maximum persistence toxicity against aphids and whiteflies. Therefore, it is suggested that plant product extract sprays may be included in eco friendly IPM program to reduce dependence on popular toxic chemicals to suppress aphid and whitefly population effectively on the potato crop. The use of these extracts can be exploited to decrease our dependence on synthetic insecticides (Chandla *et al*. 2004). The selectivity of these bioactive plant products makes them valuable in IPM of potato pests (Venkatasalam *et al*. 2011). These plant origin products provided a substantial answer to many of the problems particularly the environmental pollution. Considerable attention is now being given to incorporate the use of naturally occurring insecticides to man's armory to combat insect vectors of potato.

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